Spring 2022 EE214 Experiment 3
Transformers and MATLAB Workshop

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Contents

1 Introduction

In this experiment, transformers and MATLAB workshop, we are required to get used to plotting with MATLAB and experimented with different transformer setups. First, we are expected to observe the step-down property of the transformer. Then, the behavior of the transformer with a resistive load is expected to have experimented with different frequencies. The transformer's characteristics are needed to be formulated with an equivalent circuit. Lastly, the advantage of the impedance matching circuit setup is requested to be observed.

2 Experimental Results and Discussion

The results of the experiment are discussed in the following steps.

2.1 Step 1

In this step transformer circuit with no resistive load is examined.

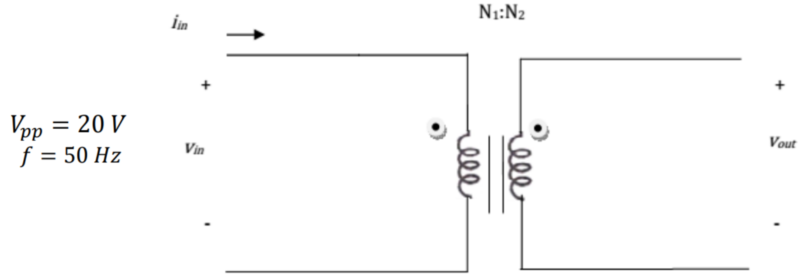

Figure 1: Circuit schematic for the step 1

In the first step, the following circuit given in Figure 1 is set, and it is observed that the step-down operation of the transformer under no load with sinusoidal input voltage has a peak to peak voltage of 20 V and frequency of 50 Hz. Then, $V_{in}(t)$ and $V_{out}(t)$ are plotted on the graph in Figure 2.

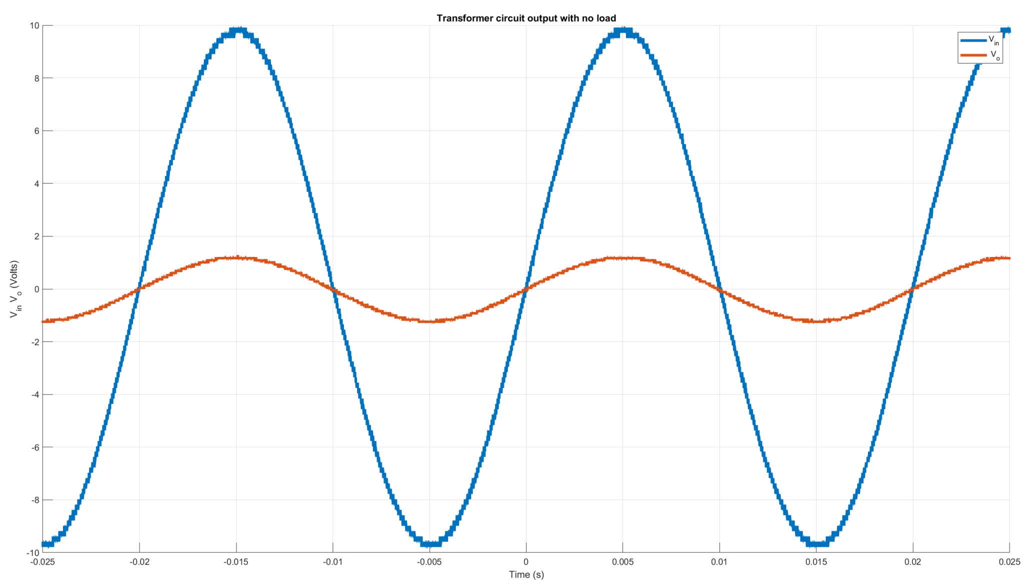

Figure 2: $V_in(t)$ and $V_out(t)$ vs Time

Afterwards, $N_1 : N_2$ ratio is measured as $\frac{19.5}{2.5} \approx 7.8$.

2.2 Step 2

In this step transformer circuit with a resistive load is examined.

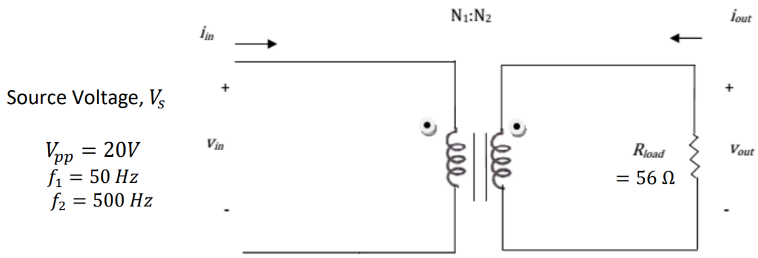

Figure 3: Circuit schematic for the step 2

For this step, the signal generator output is adjusted as $V_s = 10sin(2\pi 50t)$ with 20V peak to peak voltage and 50Hz frequency; then, the Transformer circuit with resistive load is constructed as given in Figure 3, where R = 56Ω.

2.2.1 i

In this step, to obtain current I_{in}, $1K\Omega$ resistor is connected between the - terminal of the primary side transformer and the - terminal of the signal generator. Then, CH1 is connected to the + terminal of the signal generator, and the CH2 probe is to the - terminal of the primary side transformer. By subtracting CH2 from CH1 V_{in} is obtained, and the CH2 probe of DSO gives I_{in} in mA. Afterwards, V_{in} and I_{in} are plotted in Figure 4.

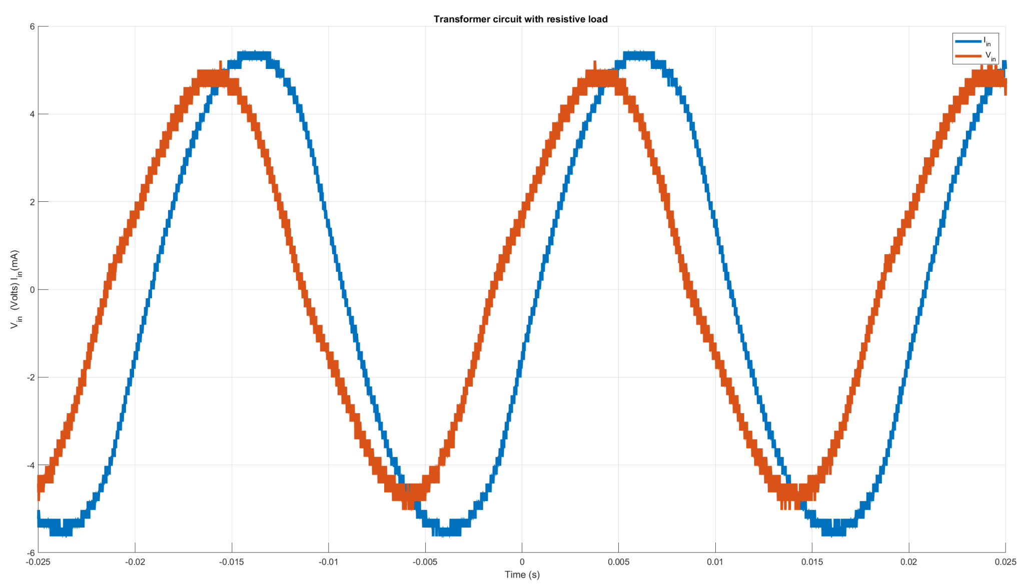

Figure 4: $V_in(t)$ and $I_in(t)$ vs Time

Then, V_{rms}, I_{rms} and $P_{in}(P_{in} = V_{rms} \times I_{rms})$ are obtained using the DSO measurement tool as 3.5V and 3.7mA, respectively, given in Table 1.

Table 1: RMS Values of input V_{rms} and input I_{rms} and P_{in}

V_{rms}	I_{rms}	P_{in}
3.5 V	3.7 mA	12.95mW

2.2.2 ii

For this step, CH1 is connected to the + terminal of the secondary side of the transformer, and from that, probe $V_{out}(t)$ is obtained and plotted as in Figure 5. Then, the RMS value of V_{out} is measured with DSO as 555mV. Then, P_{out} is calculated as $\frac{V_{out}^2}{56\Omega} = 5.5mW$. The reason for P_{out} is less than P_{in} is because the circuit is not ideal.

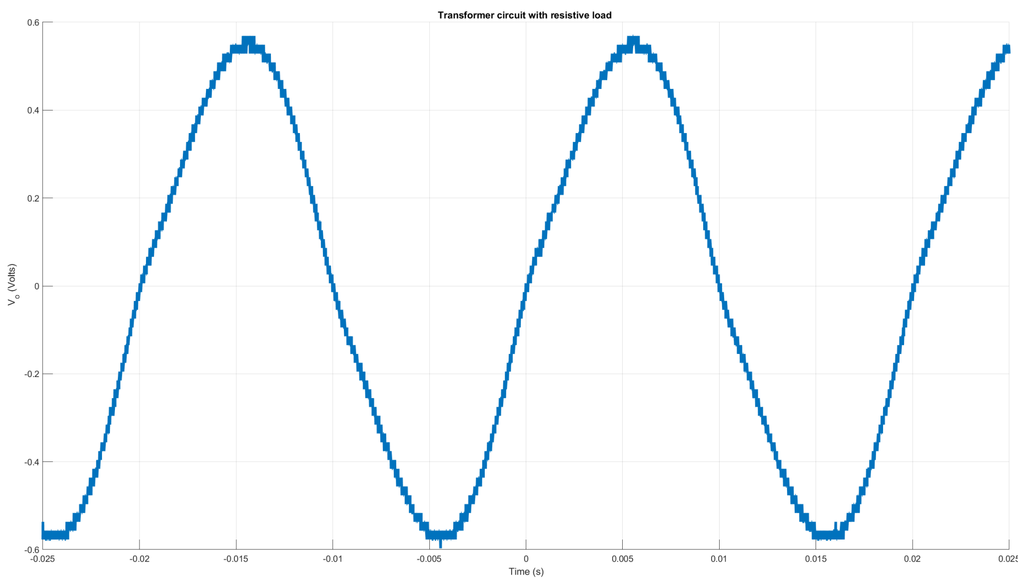

Figure 5: $V_o(t)$ vs Time

2.2.3 iii

In this step, input frequency is increased to 500 Hz, and i. and ii. are repeated. The plots given in Figures 6 and 7 are obtained.

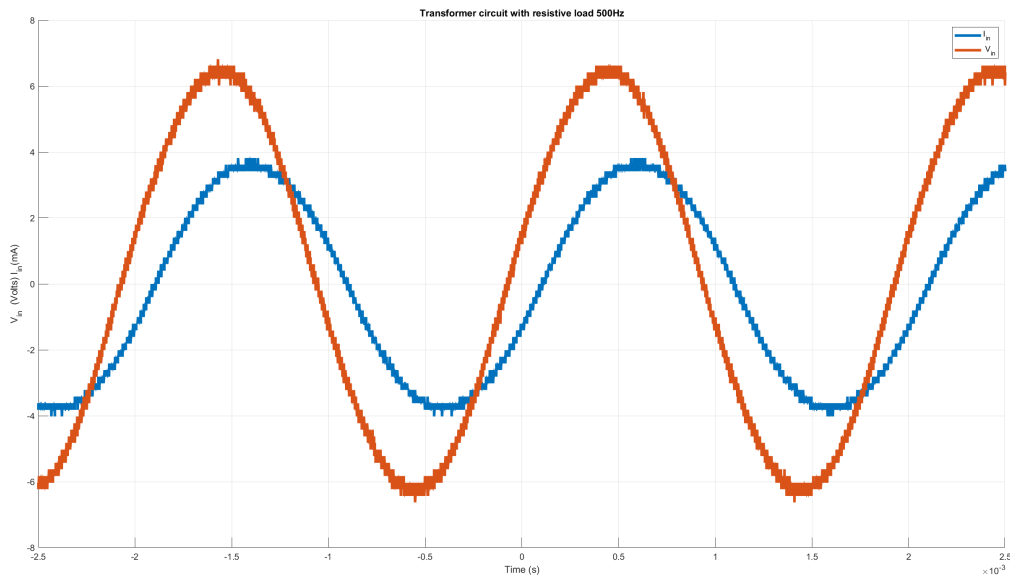

Figure 6: $V_{in}(t)$ and $I_{in}(t)$ vs Time (500Hz)

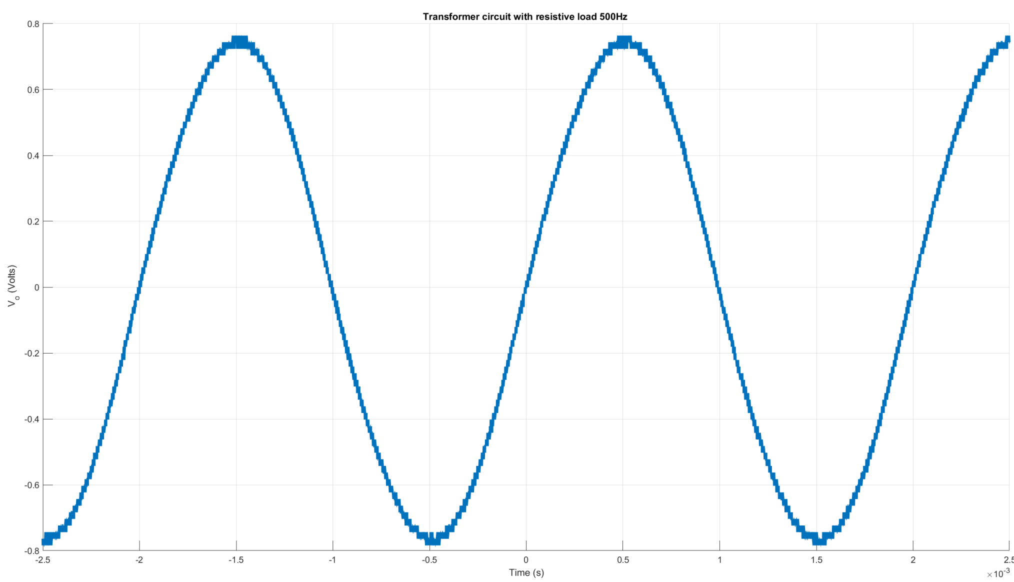

Figure 7: $V_o(t)$ vs Time (500Hz)

In previous steps (i. and ii.), the phase difference between voltage and the current was measured as $-40\,\text{deg}$, and when the frequency is increased to 500 Hz phase difference is obtained as $-25\,\text{deg}$. Therefore, it is clearly seen that as frequency increases phase difference between voltage and current decreases. But after some point, although the frequency continues to increase, the rate of change in phase difference decreases less and less.

2.3 Step 3

In this step transformer equivalent circuit is formulated by making the secondary terminal of the transformer short-circuited.

2.3.1 i

By connecting a 1KΩ resistor series to the primary terminal, we have obtained the plot given in Figure 8, which shows $V_{in}(t)$ and $I_{in}(t)$ on the same graph.

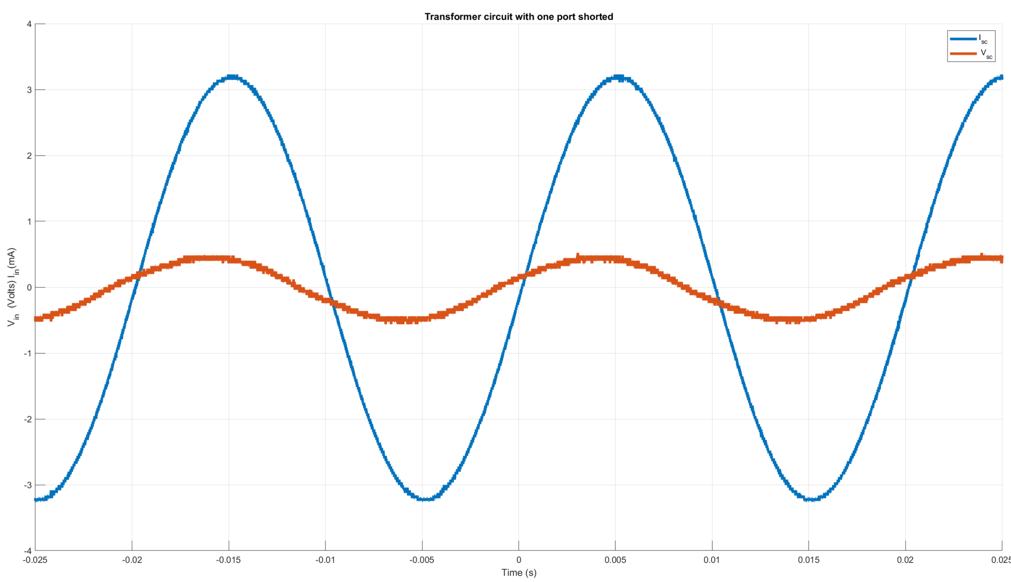

Figure 8: $V_{in}(t)$ and $I_{in}(t)$ vs Time

2.3.2 ii

A bunch of assumptions and calculations is made to obtain the equivalent circuit parameters given in Figure 9.

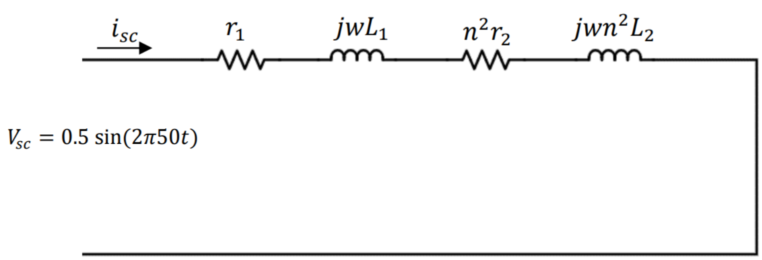

Figure 9: Transformer equivalent circuit

From the measurement feature of the oscilloscope, V_{sc-RMS} and I_{sc-RMS} are found to be 0.3345 Volts and 0.0230 Amps, respectively. So the impedance becomes;

$$Z = \frac{V_{sc-RMS}}{I_{sc-RMS}} = 150\Omega$$

The primary side of the resistance and inductance is taken equal to the reflected equivalent secondary side of resistance and inductance. The θ, phase difference is found as 23.9326 degrees. The resistance becomes;

$$R = Zcos(\theta) = 137.103$$

The reactance becomes;

$$X = Zsin(\theta) = 60.849$$

So, as a result, the parameters given in Table 2 are obtained by equating the overall resistance to R and overall reactance to X. From Step 1, n is taken as 8.

Table 2: Transformer equivalent circuit parameters

$r_1(\Omega)$	$r_2(\Omega)$	L_1 (H)	L_2 (H)
68.553	1.071	0.30425	0.00475

2.4 Step 4

In this step impedance matching transformer circuit is constructed as it is in Figure 10 with the input $V_{in}(t) = 10sin(2\pi 50t)$ and same $N_1 : N_2$ rate.

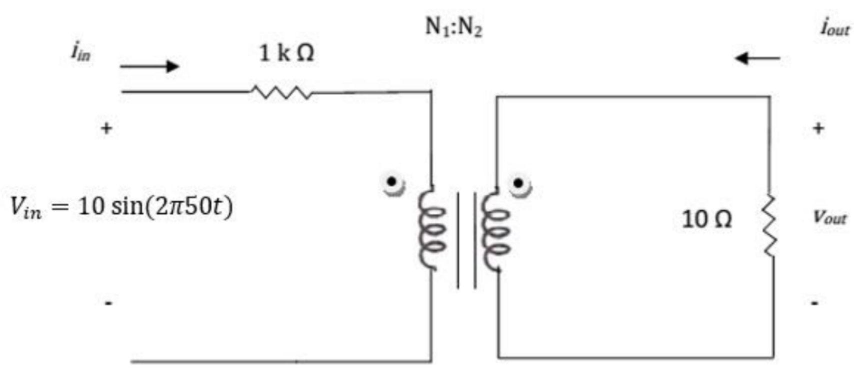

Figure 10: Impedance matching

2.4.1 i

For this step, an impedance matching transformer circuit is used. In order to obtain V_{out} CH1 is connected + terminal of the secondary side of the transformer, and power dissipated is calculated as follows:

$$\frac{V^2}{R} = \frac{(V_{rms})^2}{R} = \frac{0.216^2}{10\Omega} = 0.0046Watt$$

2.4.2 ii

For this step, 1KΩ and 10Ω resistors are connected series without the transformer and the same calculation is made in i. :

$$\frac{V^2}{R} = 4.9 \times 10^{-4}Watt$$

From these results, it is seen that in the second case, power transmitted to 10Ω from the same input is significantly smaller than in the first. Therefore, we can conclude that transformers can be used for delivering power efficiently.

3 Conclusion

In this experiment, transformers and MATLAB workshop, we got used to plotting with MATLAB and experimented with different transformer setups. First, we have observed the step-down property of the transformer. Then, the behavior of the transformer with a resistive load has experimented with different frequencies. The transformer's characteristics are formulated with an equivalent circuit. Lastly, an advantage of the impedance matching circuit setup is observed.

Appendix A

- PreLab Preparation 1 hours
- Experimental Work 2 hours
- Report Writing 6 hours